SYNOPSIS

1. Title of the Thesis:

"Investigation and Performance Comparison of Wireless Sensor Network Protocols"

2. Introduction:

The convergence of the Internet, communications and information technologies, coupled with recent advances in wireless communications and electronics have enabled the development of technically and economically feasible multifunctional sensor nodes that are small in size and communicate untethered in short distances, is paving the way for a new generation of inexpensive mobile devices, sensors and actuators. These tiny sensor nodes, which consist of sensing, data processing, and communicating components, leverage the idea of sensor networks. That bears promises for a significant impact, not only on science and engineering, but equally importantly on a broad range of applications.

Wireless sensors are sensing modules. Sensors usually compose of four basic units: a processing unit with limited computational power and limited memory, a sensing unit/sensors (including specific conditioning circuitry), a communication unit (transceiver), and a power unit (battery).

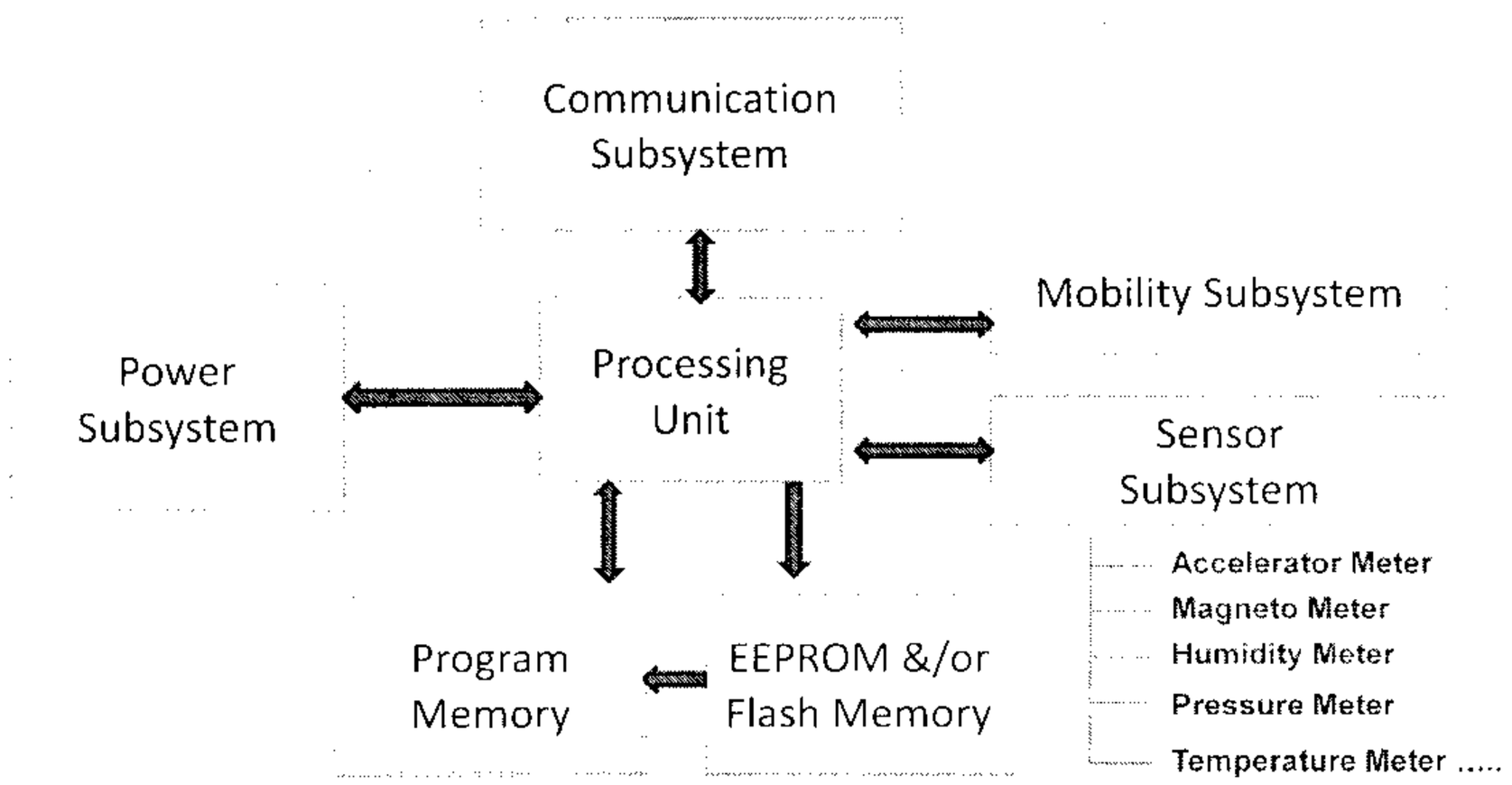

Fig.-1: The Components of a Wireless Sensor Node

It uses a various range of RF communication techniques. Through software used on the sensor may be configured to monitor various physical and environmental conditions such as mobility of objects, sound, vibration. sound, pressure. force etc.

Wireless Sensor Network (WSN) is a wireless network consisting of spatially distributed autonomous devices using wireless sensors to cooperatively monitoring and collecting data, assessing and evaluating the information, measuring the relevant quantities, formulating meaningful user interfaces, and performing decision-making and alarm functions.

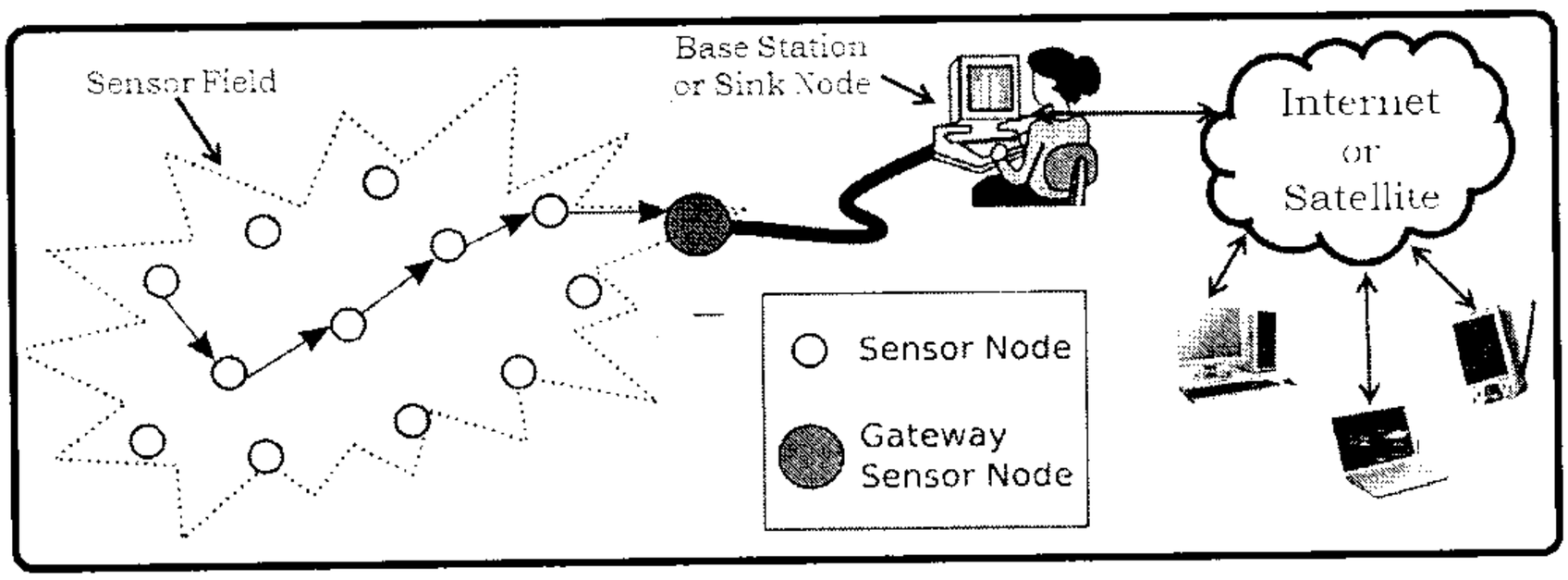

Fig.-2: Functional block diagrams of a WSN

The base stations are one or more distinguished components of the WSN with much more computational, energy and communication resources. They act as a gateway between wireless sensor nodes and the end user.

A greater number of sensors allows for sensing over larger geographical regions with greater accuracy.

A WSN normally constitutes a wireless Ad-hoc network, means each sensor support a multi-hop routing algorithm (several nodes may forward data packets to the base station).

The sensor networks can be used for various application areas relating to critical infrastructure protection and security, health care, the environment, energy, fire detection traffic monitoring, food safety, production processing, quality of life, home monitoring, object tracking etc.. For different application areas, there are different technical issues that researchers are currently resolving.

3. A brief review of the work already done in the field:

Recent advances in wireless sensor networks have led to many new protocols specifically designed for sensor networks where energy awareness is an essential consideration. Most of the attention, however, has been given to the routing protocols since they might differ depending on the application and network architecture. Kemal Akkaya, et. al [1] surveys recent routing protocols for sensor networks and presents a classification for the various approaches pursued. The three main categories explored in his paper, are data-centric, hierarchical and location-based.

In another paper Adam Chalak, et. al [2] presents a comparative study of routing protocols in Wireless Sensor Networks. Due to the limited processing power, and finite power available to each sensor node, regular ad hoc routing techniques cannot be directly applied to sensor networks domain. Adam Chalak, et. al [2] makes a performance comparison of three sensor network routing protocols; namely, Rumor routing, Stream Enable Routing (SER) and SPIN. The results show that SPIN is the most suitable for small size networks while SER serves the large-scale networks the best. Rumor is considered an alternative protocol with high delivery rate and scales from small to medium size networks.

The main task of a Wireless Sensor Network (WSN) is to collect data and either send it to a base station immediately or to store it locally until the data is requested by a base station. WSN form a wireless network without specific infrastructure thus efficient routing protocols are necessary to let a data packet find its way from one specific sensor node through the network to the base station. Since WSN are a quite new technology, in a first step existing routing protocols from other types of wireless networks have been employed in WSN. However these protocols are not well suited for WSN, since the characteristics of the technology and the application of other wireless networks may be quite different from those in WSNs. As consequence the adopted routing protocols often perform badly in the context of WSN. M. Becker, et. al [3] presents a study on usability of several routing protocols in a real world environmental monitoring task and show how the performance of wireless routing protocols can be improved significantly if adapted carefully for the use in WSN. The performance of the different available routing protocols is then measured and

compared through actual deployment of the WSN using cricket motes, which have been designed by U.C. Berkeley.

Boukerche Azzedine, et. al [4] presents applications that require fine-grain monitoring of physical environments subjected to critical conditions, such as fire, leaking of toxic gases and explosions, pose a great challenge to sensor network protocols. These networks have to provide a fast, reliable, fault-tolerant and energy-aware channel for events diffusion, which meets the requirements of query-based, event-driven and periodic sensor networks application scenarios. These requirements have to be met even in the presence of emergency conditions that can lead to node failures and path disruption to the sink. This paper proposes two routing protocols: periodic, event-driven and query-based protocol (PEQ) and its variation CPEQ, two fault-tolerant and low-latency algorithms that meet sensor network requirements for critical conditions supervision in context-aware physical environments. While PEQ can provide low latency for event notification, fast broken path reconfiguration, and high reliability in the delivery of event packets for low-network data traffic, CPEQ is a cluster-based routing protocol that groups sensor nodes to efficiently relay the sensed data to the sink by uniformly distributing energy dissipation among the nodes and reducing latency for high-network data traffic (typical in emergency situations). PEQ and its variant CPEQ use the publish/subscribe paradigm to disseminate requests across the network. We discuss both PEQ and CPEQ protocols, their implementation, and report on the performance results of several scenarios using NS-2 simulator. The results obtained are compared with the well-known directed diffusion (DD) protocol, and show that our proposed algorithms exhibit a clear indication to meet the constraints and requirements of critical condition supervision in context-aware physical environments. Paper's results indicate that PEQ outperforms DD in the average delay since it uses the shortest path for the delivery of packets and speed up new subscriptions by using the reverse path used for event notification packets. CPEQ also outperforms DD in both the average delay and in the packet delivery ratio when the network scales up.

Y. Li and T. Newe [5] presents Selection of Routing Protocol for Applications, due to the differences between Wireless Sensor Networks (WSNs) and other wireless networks, new network architectures have been developed and many new routing

protocols have been proposed for these architectures. Moreover, a wide variety of applications and systems with vastly varying requirements and characteristics have been designed and implemented. Since the selection of routing protocols for WSNs is closely related with the application requirements and routing protocol characteristics, there is no common architecture or routing protocol solution. Y. Li and T. Newe [5] presents a table that enables deployment engineers to select appropriate routing protocols that are suitable for a particular application and which will maximize the return from the deployed network.

Vlado Handziski, et. al [6] presents scalable and flexible testbed architecture for indoor deployment of wireless sensor networks named TWIST. The design of TWIST is based on an analysis of typical and desirable uses of sensor network testbeds. In addition to providing basic services like node configuration, network-wide programming, out-of-band extraction of debug data and gateway of application data, the architecture introduces several novel features, some of them exploiting the capabilities of the USB 2.0 standard. Firstly, TWIST supports different sensor node platforms. Secondly, it supports active power-control of the nodes. This enables easy transition between USB-powered and battery-powered experiments, dynamic selection of topologies as well as controlled injection of node-failures in the system. Thirdly, TWIST supports evaluation of both flat and hierarchical sensor networks. The "super nodes" that form the middle tier of the test bed infrastructure are dual-use devices that can also play a role as part of the sensor network application. The self-configuration capability, the use of standardized hardware and open-source software make the TWIST architecture scalable, affordable, and easily replicable. To demonstrate its practical value, we present our experiences with building and using a specific realization of the TWIST architecture that spans three floors of our office building and supports over one hundred sensor nodes.

Currently various survey papers and review of sensor networks with current research issues and challenges is carried out. According to these studies and with help of research papers various scenarios will be make for indoor as well outdoor in order to evaluate the performance of sensor networks.

4. Noteworthy contribution in the field of proposed work:

A detailed investigation on WSN features has been carried out to identify the key aspects & gray areas of need for a detailed research.

Efforts started with the study of background information of wireless and sensor networks, in the connection of this these points was found:

- **Resource footprint** [17, 18, 19] for various currently available Sensors/Motes provides us a summary that most of the Sensors/Motes belongs to within the following configuration:
    - 4-bit to 8-bit processor
    - 512 Byte to 512 KB RAM (Program & Data Memory)
    - 4 KB to 4 MB Flash/External Memory (EEPROM)
    - 250 Kbps 2.4 GHz IEEE 802.15.4 or Bluetooth 2.0 or 10 Kbps etc. as radio transceiver

  On the basis of above mentioned resource footprint a conclusion is made. that each and every currently available sensor nodes face limited resource problems such as narrow address space and slow clock cycle of micro controller, small program & data memory as well as external memory, low bandwidth and low range of transceivers.

- After evaluating various research papers it was found that there are 40 Operating Systems (TinyOS, Contiki, MantisOS, SOS, Microsoft .NET Micro, YATOS, BTnutOS/NutOS, PeerOS, Embedded Linux, NanoRK, µCOS, Squawk VM, SensorOS, MagnetOS, CORMOS, Bertha, kOS, VMSTAR, Maté, CVM, EYES, SenOS, DCOS, t-Kernel, Nano-QPlus, SmartOS, AVRX, Pixie, LiteOS, T2, OSSTAR, Jallad, CustomOS, GenOS, MoteWorks, NanoVM, ParticleVM, KVM, AmbiCompVM, SENSIX) running on different wireless sensor nodes.

  Each operating system has its own architecture and resource management techniques thus it may be possible that there architecture can affects Routing Mechanisms in WSNs.

- Wireless Sensor Networks are "Data Centric" in nature, because they are deployed for measuring physical environmental conditions such as pressure, temperature, humidity etc.

- Unique identification schemes cannot be effectively used in sensor networks. due to large no. of deployment/manufacturing and resource constraint nature of sensor nodes.

A study with respect to concepts, characteristics, current status, applications areas, and various algorithms & protocols has been carried out.

- Routing is a very challenging task in WSNs due to several characteristics that distinguish them from other communication networks & wireless Ad-hoc networks. Performance of routing protocol closely related to architectural model. Routing protocols in sensor networks will have to deal with:
    - Scalability (using distributed control and local interactions)
    - Energy efficiency
    - Robustness (maintain connectivity)
    - Load balancing in terms of energy used by nodes
    - Low Latency
    - Minimum computation and memory usage

- WSN routing protocols can be broken down based on the following categories:

Routing techniques in WSNs can be divided into three categories depending on the network structure:

1. *Flat-based (Data Centric) routing*
2. *Hierarchical-based (Clustering) routing*
3. *Location-based routing*

Furthermore Routing protocols in WSNs can be divided into five categories depending on the protocol operation:

1. *Multipath-based routing*
2. *Query-based routing*
3. *Negotiation-based routing*
4. *QoS-based routing*
5. *Coherent-based routing*

- Routing in WSNs is very challenging due to the inherent characteristics that distinguish these networks from other wireless networks like mobile ad hoc networks or cellular networks.

    - First, due to the relatively large number of sensor nodes, it is not possible to build a global addressing scheme for the deployment of a large number of sensor nodes as the overhead of ID maintenance is high.
    - Second, in contrast to typical communication networks, almost all applications of sensor networks require the flow of sensed data from multiple sources to a particular BS.
    - Third, sensor nodes are tightly constrained in terms of energy, processing, and storage capacities. Thus, they require careful resource management.
    - Fourth, in most application scenarios, nodes in WSNs are generally stationary after deployment except for, may be, a few mobile nodes.
    - Fifth, sensor networks are application specific, i.e., design requirements of a sensor network change with application.
    - Sixth, position awareness of sensor nodes is important since data collection is normally based on the location.
    - Finally, data collected by many sensors in WSNs is typically based on common phenomena, hence there is a high probability that this data has some redundancy.

With this study it is evident that there is a need for detailed assessment & investigation in the routing mechanism aspects of WSNs in order to enhance the performance under various scenarios.

A number of research papers is made in the field of Wireless Sensor Networks, these papers is to be sent to publish on National Conference/ International Conference/ Journals.

Hence the present topic "**Investigation and Performance Comparison of Wireless Sensor Network Protocols**" has been chosen, being an emerging area for research.

5. Proposed methodology during the tenure of the research work:

For different application areas, there are different technical issues that researchers are currently resolving. Due to the limited processing power, and finite power available to each sensor node, regular ad hoc routing techniques cannot be directly applied to sensor networks domain. Thus, energy-efficient routing algorithms suitable to the inherent characteristics of these types of networks are needed. Routing algorithms must also be robust to failures, and provide low latency as well as energy awareness is an essential design issue for WSNs protocols.

Efforts started with the study of background information of wireless and sensor networks, A study with respect to concepts, characteristics, current status, applications areas, and various algorithms and protocols has been made and to achieve the above said goal the proposed methodology and action plan is as follows:

- Study of various Simulators for the proposed investigation and performance comparison of Wireless Sensor Networks protocols.
- Choice of study of the protocols to be evaluated.
- Sensitivity analysis and parameterization of significant simulators.
- Choice of parameters for which the protocols are to be evaluated.
- Choice & use of the Simulators for detailed investigation and performance comparison.
- Study of various WSN routing protocols with their relative merits and demerits with the consideration of scenarios where they can be deployment.
- Prepare comparative performance report for the existing protocols, highlighting the performance issues with respect to various parameters
- Highlight superior concepts of protocols in order to increase the efficiency and performance.
- Analysis & Comparative study of the Routing Mechanisms under various scenarios.

- If, found necessary for some scenarios then new protocols should be proposed or enhancements/changes in protocols can be done

Tools:

- A detailed survey on various literature and research papers for simulators was performed, it was found **38 Simulators** (TOSSIM, TOSSF, NS-2, Mannasim, SENSE, OMNet++, Castalia, J-Sim, GloMoSim, Qualnet, Visual SENSE, AlgoSenSim, GTNetS, Atemu, JIST SWANS, JIST SWANS++, Avrora, Sidh, PARSEC, LecsSim, Prowler, (J)Prowler, SENS, EmStar, EmTOS, SensorSim, OPNET, Shawn, SSFNet, COOJA, SOS Simulation Framework, PowerTOSSIM, SenSor, SensorMaker, SNetSim, SimSync, SimGate, T-ANT), each one has its own design goal and pros & cons under various conditions.

- For current requirement after evaluating various simulators, ATEMU (is a Sensor Network Emulator/ Simulator/ Debugger) is to be selected, whose primary strength is its accuracy. In future some other tools can also be selected to achieve the above described goal that is "Investigation and Performance Comparison of WSNs Protocols".

If at the later stage, evaluation & investigation of various routing algorithms and traffic management features may be taken up as per developments.

6. Expected outcome of the proposed work:

As the sensor network routing protocols are being explored by efficient specialized groups for different purposes, our work proposes to perform an extensive study of various Wireless Sensor Networks routing mechanisms, in particular the Protocols with their relative merits and demerits for various scenarios and purposes.

Expected outcome is a detailed investigation, analysis and performance comparison of the various Wireless Sensor Networks routing protocols under various scenario conditions and specialized purposes.

If found necessary the work might propose possible enhancement in the existing routing algorithms and protocols for more efficient functionality and internetworking aspects of Wireless Sensor Networks scenarios.

7. Contribution in the field of WSN

International Conference/Journal

S. No.	*Research Paper Title*	*Authors*	*Conference/Journal*	*Status*
1.	Operating Systems for Tiny Networked Sensors: A Survey	**A.K. Dwivedi, M.K. Tiwari, O.P. Vyas**	**International Journal of Recent Trends in Engineering (Computer Science),** [Page 152-157] Vol. 1, No. 2 Organized By: Association of Computer Electronics and Electrical Engineers (**ACEEE**).	**Accepted** **Remark:** Published by Academy Publisher, Finland with [ISSN 1797-9617, ISBN 978-952-5726-04-6 (Print); ISBN 978-952-5726-05-3 (CD-ROM)]
2.	Evaluating Impact of Wireless Sensor Node's O.S. Architectures on Simulation Results of Routing Mechanisms for Wireless Sensor Networks	**A.K. Dwivedi, Anil Sharma, M.K. Tiwari, O.P.Vyas**	**The 8th Annual IEEE Conference on Sensors IEEE SENSORS 2009 Conference** Date: 25th to 28th Oct, 2009 Organized At: Christchurch Convention Centre 95 Kilmore Street Chirstchurch, Canterbury 8013 New Zealand	**Communicated**

National Conference/Journal

S. No.	*Research Paper Title*	*Authors*	*Conference/Journal*	*Status*
1.	A Survey on Security Breaches and Countermeasures in Wireless Sensor Networks	**O.P. Vyas, M.K. Tiwari, A.K. Dwivedi**	**National Conference** on Emerging Trends in Information Technology (NCETIT)-08. Date: 1st & 2nd Nov., 2008 Organized At: GIET, Dist. Rayagada, Orissa, India.	**Accepted and Published**

2.	A Review on Classification of Operating Systems for Wireless Sensor Networks	**Anil Sharma, A. K. Dwivedi**	**National Level Colloquium** on Mobile Communication and Data & Knowledge Engineering. Date: 2nd & 3rd Jan., 2009 Organized At: S.o.S. in C.S. & I.T., Pt. Ravishankar Shukla University, Raipur, C.G. India.	**Accepted and Published**
3.	Programming Languages for Wireless Sensor Networks: A Comparative Study	**Sunita Kushwaha, A. K. Dwivedi**	**National Level Colloquium** on Mobile Communication and Data & Knowledge Engineering. Date: 2nd & 3rd Jan., 2009 Organized At: S.o.S. in C.S. & I.T., Pt. Ravishankar Shukla University, Raipur, C.G. India.	**Accepted and Published**
4.	A Review of Security in Wireless Sensor Networks for Indoor Application Scenario: Prospects and Challenges	**O.P. Vyas, M.K. Tiwari, A.K. Dwivedi**	**National Conference** on "Wireless Communication and Networking" (WINCON)-09. Date: 9th & 10th Jan., 2009 Organized At: L&T Institute of Technology, Mumbai, Maharashtra, India.	**Accepted and Published**
5.	Implementation Challenges of IPv6 on Wireless Sensor Networks	**A.K. Dwivedi, Bhisham Sonkar, O.P. Vyas**	"**National Conference** on Advances in Computer Applications" NCACA-09 Date: 7th & 8th May, 2009 Organized At: Sri Siddhartha Institute of Technology, Maralur, Tumkur, Karnataka, India.	**Accepted**
6.	A Stance on Challenges with Current Internet and Approaches for Future Internet	**Bhisham Sonkar A.K. Dwivedi, O.P. Vyas**	"**National Conference** on Advances in Computer Applications" NCACA-09 Date: 7th & 8th May, 2009 Organized At: Sri Siddhartha Institute of Technology, Maralur, Tumkur, Karnataka, India.	**Accepted**

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